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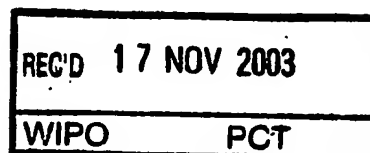WIPO   PCT

CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 21 October 2002 with an application for Letters Patent number 522153 made by JOHN BLAKEMORE HARRISON.
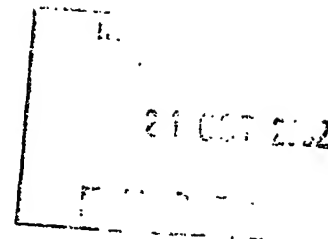
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Neville Harris

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NEW ZEALAND

522153

METHOD AND APPARATUS FOR FUEL INJECTION SYSTEMS

I, **JOHN BLAKEMORE HARRISON,** a citizen of New Zealand, of 216 Whitford Road, Howick, Auckland, New Zealand do hereby declare this invention to be described in the following statement:

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METHOD AND APPARATUS FOR FUEL INJECTION SYSTEMS

Background

The present invention relates to a method and apparatus for use in fuel injection systems, which term is used to describe such systems in all types of uses, industrial, vehicular, domestic and the like.

With the increasing worldwide concerns relating to pollution, the use of electronically controlled fuel injection systems for vehicle engines and in industrial applications such as boilers, is becoming increasingly popular. This is due to their superiority in providing a close control of fuel/air ratios which in turn controls the amount of pollution resulting from the vehicle or boiler exhaust for example.

In order to control the flow of gaseous fuel in a fuel injection system, there is a problem in finding a solenoid valve or other control means which will be large enough to control a sufficient volume of gas while at the same time be able to operate at a high enough speed. The larger the gas flow, the larger and slower the solenoid valve or the like needs to be.

Objects of the Invention

It is therefore an object of the present invention to provide a method and/or apparatus for use in a gaseous fuel injection system which will overcome or at least obviate problems inherent in such methods or apparatus to date or which at least will provide the public with a useful choice.

Brief Summary of the Invention

According to one aspect of the present invention there is thus provided a method of controlling the flow of gaseous fuel in a fuel injection system, said method comprising:

(i) Providing a first chamber connectable with a source of gaseous fuel at a required inlet pressure;

(ii) Providing a second chamber connectable with an engine or other apparatus and in gas flow connection with said first chamber through a controllable valving means;

(iii) Providing a flow control means having an inlet connected with said first chamber to receive gaseous fuel therefrom and an outlet connected with an orifice means so adapted

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that the outlet pressure of said flow control means is no greater than 53% of the said inlet pressure;

(iv)   Said method further comprising the control of said gaseous fuel flow by said flow control means, so as to control the said outlet pressure and detecting said outlet pressure to control said valving means so as to control the pressure in said second chamber and therefrom the gaseous fuel flow to said engine or other apparatus from said second chamber.

According to a further aspect of the present invention there is provided an apparatus for a gaseous fuel injection system utilising the above defined method.

According to a further aspect of the present invention there is provided an apparatus for a gaseous fuel injection system comprising:

(i)   A first chamber connectable with a source of gaseous fuel at a required inlet pressure;

(ii)   A second chamber connectable with an engine or other apparatus so as to supply gaseous fuel thereto and further connected with said first chamber through a controllable valving means;

(iii)   A flow control means having an inlet connectable with said first chamber and an outlet connectable with an orifice means for controlling the pressure at the outlet of said flow control means to be no more than 53% of the inlet pressure;

(iv)   Detection means for detecting said outlet pressure for controlling said valving means;

(v)   The arrangement being such that controlling the said flow control means to adjust the flow of gaseous fuel therethrough controls the said outlet pressure which in turn controls said valving means and the pressure in said second chamber and so as to thereby control the flow of gaseous fuel to said engine or other apparatus.

According to a further aspect of the present invention there is provided a method and/or apparatus substantially as herein described with reference to Figure 1 of the accompanying drawings.

Further aspects of this invention which should be considered in all its novel aspects will become apparent from the following description given by way of example of possible embodiments thereof and in which reference is made to the very diagrammatic illustration of possible embodiments in the accompanying drawings.

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Brief Description of the Drawings

Figure 1   shows diagrammatically one possible embodiment of the invention.

Brief Description of Possible Embodiments

As mentioned above, a particular problem with gaseous fuel injection systems is to be able to control a relative large gas flow without using correspondingly large and relatively slow control apparatus and in particular large and slow solenoid operated apparatus.

In attempting to deal with this problem the present invention has made use of an application of Bernoulli's Principle which in the present context can be summarised as follows:

(a)   In general, the gas flow through an orifice is proportional to the square root of the pressure differential across the orifice, except where

(b)   The absolute outlet pressure of the orifice is not more than 53% of the absolute inlet pressure, when the flow will be proportional to the square root of the absolute inlet pressure,

(c)   The converse of both (a) and (b) being that, the pressure required to produce a given flow is proportional to the flow squared.

In utilising the above physical law, the present invention seeks to ensure that the absolute outlet pressure at the outlet orifice of a gas flow control means is never more than 53% of the absolute inlet pressure which will mean that the flow is kept constant for a particular flow control means setting. By then detecting and using the outlet pressure to control the pressure in a chamber supplying the gas to the engine or boiler or the like, a very small gas flow through the flow control means can then control a very much larger gas flow to the engine or boiler or the like. It follows therefore that the flow control means can be a relatively small and fast device in that it is only controlling a small gas flow, although it is in fact then controlling a very much larger gas flow.

Referring to Figure 1 of the accompanying drawings, the present invention in one embodiment is shown very diagrammatically as having a first chamber 2 connected with a

gas fuel supply providing a gas flow indicated by arrow 1. The inlet gas supply will be at a constant or substantially constant pressure.

The chamber 2 is then shown connected through an outlet 7 with a flow control means 8. In this illustrated embodiment of this invention the control means 8 is in the form of a solenoid valve with its coil 20 illustrated through which the controlling electrical pulses will be supplied so as to switch the solenoid valve 8 rapidly on and off. Such small very high speed solenoids (HSS) will be well known to those skilled in the engineering arts, typical examples being Bosch model No 0-280-150-215 or model HSV3000 of Servojet Products International, these being given solely by way of example only and merely indicative of possible types of high speed solenoid valve which may be used.

The outlet of the solenoid valve 8 is shown provided with an orifice 18 extending into a chamber 9. The outlet of the chamber 9 then feeds into an outlet 19 which typically would be fed to the engine or boiler so that there would be no wastage of gas. In the outlet line 19 there is shown an orifice 11 the size of which is such that at the maximum flow of gas through the solenoid 8, the outlet pressure at the orifice 18 of the solenoid 8 will be no more than 53% of the gas inlet pressure at inlet 1 and chamber 2. By way of example only, at maximum gas flow through solenoid 8 the inlet pressure could be for example 800kPa abs (700kPa gauge) with the outlet pressure at the solenoid valve 8 then being no more than 400kPa abs (300kPa gauge). For simplicity, the system may aim for an absolute outlet pressure of the solenoid valve 8 which is never more than 50% of the inlet pressure.

In view of the aforementioned pressure/rate of flow law, with this relationship between the inlet and outlet pressures, the rate of flow of gas through the solenoid 8 will be a constant because the inlet pressure is a constant. The net flow will therefore be solely dependant on the control of the solenoid valve 8, i.e. on the on/off ratio, commonly called the "duty" cycle.

With the previously stated relationship between pressure and any given flow, namely pressure being proportional to the flow squared, the pressure in the chamber 9 will therefore be that which is required to provide the level of gas flow through the solenoid valve 8 and through the orifice 11.

It will also be appreciated that due to the mentioned relationship between pressure and gas flow, if the control on the solenoid valve 8 is changed so that it operates at a higher duty, for example 10% as against 5% then the gas flow will double but the pressure in the chamber 9 will increase four fold, i.e. 2^2. If the solenoid duty was increased three fold then the pressure in the chamber 9 would increase nine fold, i.e. 3^2.

It will be appreciated that the pressure in chamber 9 will be subjected to the diaphragm 4 shown connected very diagrammatically with a valve stem 3A and a valve head 3 of control valve 6, the valve head 3 controlling an opening through a bottom wall 2A of chamber 2. The valve arrangement 3, 3A is shown very diagrammatically as being balanced by a balancing spring 16 mounted in a threaded holder 15 screwed into the bottom wall 14 of chamber 6 and adjustable by means of nut 13. The spring 16 suitably imposes a very lightweight force on the diaphragm 4 and valve stem 3A so as to just maintain the opening through the chamber wall 2A closed by the valve head 3. This is so as to result in a slight increase in pressure being detected in chamber 6 being sufficient for the valve 3 to open. Under normal operating conditions, the spring force will be negligible compared to the existing pressures so that it will only have a minimal effect on the operation of the system after start up or a change of flow rate.

It will be seen that the pressure in chamber 9, reflects the gas flow through the orifice 11 and outlet 19.

Due to the chambers 5 and 9 being separated by diaphragm 4, which in turn is controlling the operation of the valve 3, the pressure in chamber 5 will try and equal that in chamber 9, so the resultant gas flow through outlet 12 to the engine or boiler will be proportional to the square root of the pressure in chamber 5 and therefore directly proportional to the gas flow which has been set by means of solenoid 8.

Suitably, the on/off ratio of the solenoid 8, i.e. its duty cycle, will be determined by an engine or boiler management computer operating so as to control the net volume of gas flow through the solenoid 8, orifice 18 and orifice 11. The resultant pressure in chamber 9 reflecting the level of gas flow set by the solenoid 8, will then provide an upward force on the diaphragm 4 to open the valve 6 and provide for the gas flow through the valve 6 into the chamber 5 and out through the injector outlet 12 to the engine or boiler or the like.

Orifice 10 provides a gas pressure feed from chamber 1a to chamber 2. As valve head 3 lifts the pressure in chamber 2 bleeds into chamber 5 resulting in a pressure difference between chambers 1a and 2. Diaphragm 2a is subjected to this pressure difference, resulting in a diaphragm lifting and thereby allowing the inlet gas from chamber 1a to flow via the main control valve 6 down into chamber 5. It should be noted that as diaphragm 2a lifts in this manner the valve head 3 will effectively close the central orifice in the diaphragm 2a thereby resulting in a new equilibrium of pressures between chambers 1a and 2.
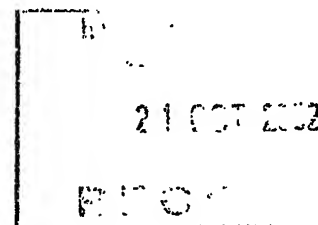
Due to the presence of the orifice of injector 12 which restricts the gas flow, the pressure in the chamber 5 will increase until it balances the pressure in the chamber 9. It is seen therefore that the pressures across the injector orifice 12 and orifice 11 will be the same with the result that the gas flow through the injector 12 will also be proportional to the set flow through orifice 11 being in turn that set by the solenoid valve 8.

The relatively small gas flow through outlet 19 can therefore be controlled by a small high speed solenoid 8 or other flow control means while simultaneously providing a corresponding control over the much larger gas flow through the injector 12 to supply the engine or boiler or the like.

Where in the foregoing description reference has been made to specific components or integers of the invention having known equivalents then such equivalents are herein incorporated as if individually set forth.

Although this invention has been described by way of example and with reference to possible embodiments thereof it is to be understood that modifications or improvements may be made thereto without departing from the scope or spirit of the invention.
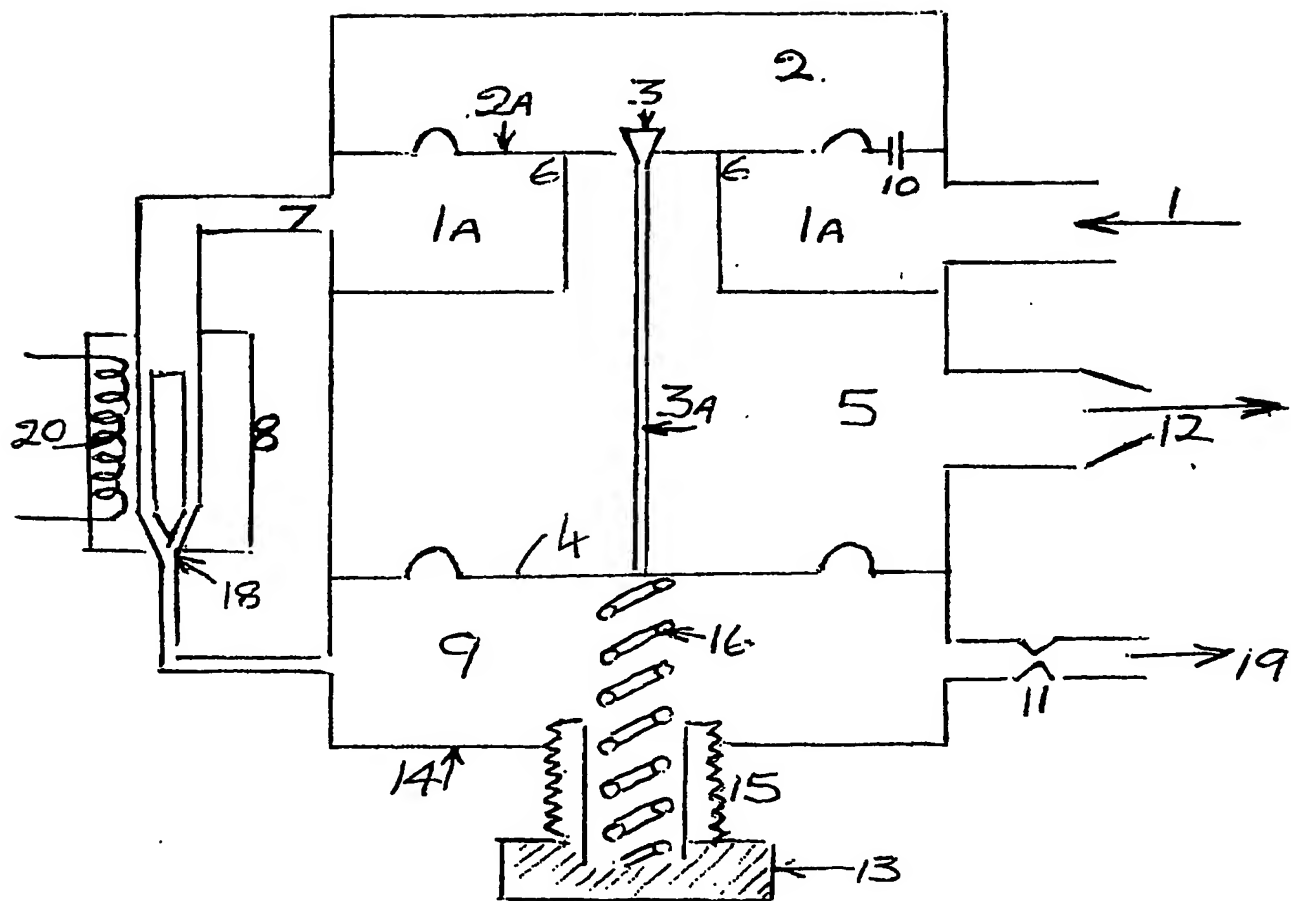
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FIGURE 1